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PPPs: Purchasing Power or Producing Power Parities?

by John R. Baldwin and Ryan Macdonald

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.	not available for any reference period
..	not available for a specific reference period
...	not applicable
0	true zero or a value rounded to zero
0^s	value rounded to 0 (zero) where there is a meaningful distinction between true zero and the value that was rounded
^{p}	preliminary
^{r}	revised
x	suppressed to meet the confidentiality requirements of the *Statistics Act*
^{E}	use with caution
F	too unreliable to be published

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Abstract

This paper examines the different types of deflators that are used to compare volume estimates of national income and production across countries. It argues that these deflators need to be tailored to the specific income concept used for study. If the potential to spend concept is employed, a purchasing power deflator is needed. If a production based concept is used, a producing power deflator is necessary. The paper argues that present practice produces a hybrid deflator that fails both purposes when terms of trade shifts are large and offers a solution.

Executive summary

There are two potential ways to make cross-country comparisons using estimates of income derived from National Accounts programs of different countries. Each requires a different deflator in order to transform measures of the dollar value of production (or income produced) measured in different currencies (dollars, sterling, euros), into measures of relative volumes of production (sometimes referred to as 'real' value added) or relative real income. These deflators are referred to as PPP deflators.

PPP programs can be devised to measure either *purchasing* power parities or *producing* power parities. The measure required depends on the purpose of the analysis.

Indices of *purchasing* power parity are used to compare real income levels across countries based on a nation's ability to buy goods and services. Purchasing power parity comparisons deflate the relative levels of nominal income (often referred to as gross domestic product (GDP)) using price indexes derived from prices for final domestic expenditures (primarily consumption, investment and government expenditures). When domestic prices, rather than domestic and traded prices, are used to calculate real income, the resulting measure is referred to as real Gross Domestic Income (GDI).

Indices of *producing* power parities are also used to compare real estimates across countries. Producing power parity estimates are used to examine production-related phenomenon—differences in countries' ability to produce (as opposed to consume), goods and services. Producing power parity comparisons employ relative estimates of real GDP. In nominal dollar terms, GDP is equal to the income generated in production. When GDP is used to compare the volume of production across countries, a deflator is required that compares the prices of production—not the prices of expenditures.

In a world without trade between countries, the purchasing power and producing power parities will be identical, since then the commodities that a nation produced would be those that the country consumed. But in a world where trade occurs, prices that are made up of commodities produced need not correspond to the prices of commodities consumed.

In this note, we examine the differences in the purchasing power and producing power parity measures for Canada relative to the US, elaborate on differences between the two, and discuss problems of estimation.

This paper analyzes PPP concepts based on GDI and argues that these are appropriate for comparing the well being of Canadians relative to Americans. In doing so it examines several questions:

- Why is it important to use real GDI rather than real GDP?

  Real GDP and real GDI differ with respect to the manner in which changes in the terms of trade (differential movements in export and import prices) are treated. The GDP deflator treats terms of trade changes as price effects and, as a result, it corresponds to a volume index measured in products produced. The GDI deflator treats terms of trade changes as volume changes and leaves them in the real income measure. Consequently, it produces a volume index measured in terms of products that can be absorbed by the domestic community through expenditures.

Because Canada is a small open economy that trades extensively, terms of trade changes exert significant influence on Canadian's ability to transform their earnings into consumption and investment. During periods of rapid terms-of-trade change, growth in real GDI can outpace real GDP growth. International comparisons of real income growth based on real GDP will understate Canada's gains in real income when the terms of trade improve.

- How large is the purchasing power of the Canadian economy relative to the American economy?

The purchasing power estimate varies depending on the year in question. During the 1960s Canada's purchasing power was near parity with the United States. During the 1970s and early 1980s, Canada's purchasing power declined. The late 1980s and 1990s saw little change in the PPP estimate, which settled in the 80%-to-85% range. During the resource boom after 2002, Canada's purchasing power increased, rising above 90% of the U.S. level by 2008.

- Can PPPs be devised to compare productivity between countries?

Yes, but a set of PPP estimates that are suitable for comparing real GDI cannot be used to produce estimates of real GDP. Real GDP can be used to compare productivity between countries; however, national statistical systems are not set up to readily provide the necessary information for calculating a producing power estimate that is suitable for comparing GDP on an ongoing basis.

The traditional method for calculating real GDP-based PPPs requires detailed knowledge about export and import prices as well as domestic prices. It is differential movements in export and import prices that must be removed from aggregate nominal income to arrive at the real GDP measure. PPP estimates that assume the same deflator, like a market based exchange rate, for exports and imports apply the same deflator to both aggregates and do not account for terms of trade adjustments.

An alternative method using estimates of gross outputs and intermediate inputs can be used to calculate GDP-based PPPs. However, these estimates continue to suffer from a lack of reliable data sets containing coherent, comprehensive and comparable information across countries. As a result, they are less accurate than GDI-based PPPs.

1 Introduction

There are two potential ways to make cross-country comparisons using estimates of income derived from National Accounts programs of different countries. Each requires a different deflator in order to transform measures of the dollar value of production (or income produced) measured in different currencies (dollars, sterling, euros), into measures of relative volumes of production (sometimes referred to as 'real' value added) or relative real income. These deflators are referred to as PPP deflators.

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In a world without trade between countries, the purchasing power and producing power parities will be identical, since then the commodities that a nation produced would be those that the country consumed. But in a world where trade occurs, prices that are made up of commodities produced need not correspond to the prices of commodities consumed.

In this note, we examine the differences in the purchasing power and producing power parity measures for Canada relative to the United States, elaborate on differences between the two, and discuss problems of estimation. We argue that the accuracy of the two estimates differs substantially and that, for practical reasons relating to quality of product, the primary emphasis of a PPP program should be on purchasing power prices.

2 Real gross domestic product versus real gross domestic income

Before discussing purchasing power and producing power parities, it is useful to discuss the difference in the deflators used to produce time series estimates of 'real' GDP and 'real' GDI because we argue there is a close parallel when it comes to producing cross-country estimates of purchasing power and producing power parities.

An estimate of real GDP is calculated by removing the impact of changing prices on domestic production. This is done by deflating using the GDP deflator.

$$\text{Real GDP} = \frac{\text{Nominal GDP}}{P_y} = Q_y \tag{1}$$

Since production and income are equivalent in the System of National Accounts, this produces a measure that can be considered both a production and a 'real' income measure. When it is used as a measure of changes in real income over time, it captures changes in the volume of production. Terms-of-trade shifts that come from different movements in export and import prices are treated as price effects that do not influence growth in real income. Real income is measured here only in terms of the prices of net outputs produced, and its changes are therefore associated with movements relating to the economy's production function.

In contrast, changes in real GDI are generated by deflating changes in the nominal value of income by a price deflator that depends only on the prices of domestic expenditures. The result is a measure of changes in real income that is associated with a country's utility curve (Kohli 2004). Measures of changes in real GDI allow changes in both production and relative prices of exports, as opposed to imports, to influence the course of this measure of real income over time.

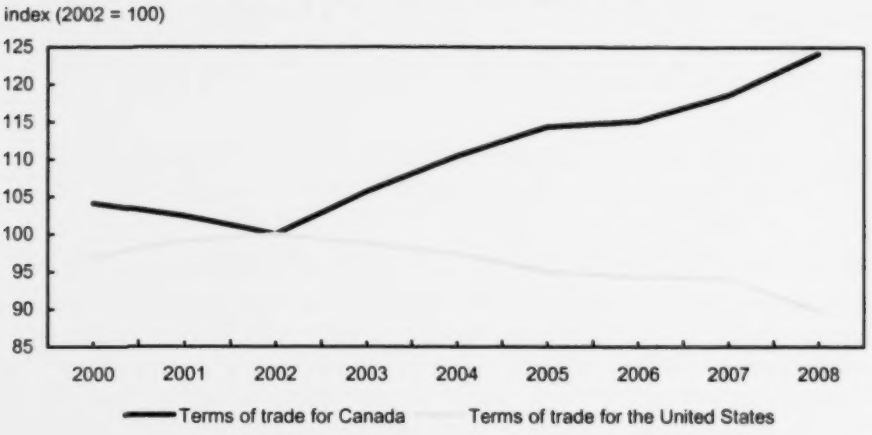
$$\text{Real GDI} = \frac{\text{Nominal GDP}}{P_{fde}} = Q_y \frac{P_y}{P_{fde}} \tag{2}$$

The difference between changes in a measure of real income derived from using domestic production prices, and a measure of real income derived using domestic expenditure prices, comes from what is referred to as a trading gain, and is primarily the result of terms-of-trade changes (the difference in changes in import and export prices).[1] It occurs because changes in the relative prices of exports and imports create potential increases (or decreases) in what can be purchased internationally in the way of imports from a country's exports. Trading gains lead to a volume effect that influences real domestic absorption. During periods when terms of trade changes are large, significant differences emerge between measures of real GDP and real GDI. Across developed nations, the changes in the trading gain are important sources of growth in consumption and investment when terms of trade shocks occur.[2]

Changes in the terms of trade can be quite large. Between 2002 and 2008, commodity prices increased sharply on international markets. For Canada, this generated a significant increase in the price of its exported products, which contributed to an appreciation of its currency relative to U. S. currency, and to a decline in its import costs. The result was a rapid increase in Canada's terms of trade (Chart 1). For the United States, the increase in commodity prices, particularly energy, decreased the terms of trade.

1. See Macdonald (2007a, 2007b).
2. See Macdonald (2010).

Chart 1
Terms of Trade for Canada and the United States



The magnitude of changes in the terms of trade affected how rapidly real income measures progress over time relative to GDP. Real GDP and real GDI treat the terms of trade in fundamentally different ways. Real GDP calculations assume the terms of trade are a price effect, while real GDI calculations assume the terms of trade are a volume effect. As a result, when a country's terms of trade improve, its real GDI growth will accelerate relative to its real GDP growth.

The differential treatment of the terms of trade between real GDP and real GDI arises from differences in the treatment of import and export prices in their respective deflators. The GDP deflator uses separate import and export prices, which allows real GDP to track movements in a country's production function by focusing solely on the volume of production. This is the relevant procedure needed for examining changes in productivity. The GDI deflator uses the same price index, in this case the final domestic expenditure deflator P_{fde}, for both exports and imports. As a result, relative price changes between exports and imports are not removed from the real income metric through deflation. This allows real GDI to track movements in the purchasing power of domestically generated income. This is the relevant approach for measuring domestic absorption and making international comparisons of well-being based on expenditure measures. Choosing the deflator used on the net export term as the implicit deflator taken from domestic expenditure allows measurement of increases in real income that are generated by three factors—changes in domestic production, the terms of trade, and the real exchange rate (the ratio of the prices of non-tradables to tradables).

When calculating a purchasing power parity that is to be used for estimating the relative purchasing capability of income across countries, similar logic dictates that the deflator be generated from final domestic expenditures. The level calculation for reference-year purchasing power parity estimates should be based on a real GDI concept. Real GDI is calculated using a deflator for C, I, G and Inventories. No export or import prices are necessary. The level comparison is based only on the relative prices of goods and services sold on domestic markets.

The level calculation for producing power parity estimates should be based on a real GDP concept. This requires calculation of relative prices of commodities, either gross outputs and intermediate inputs, or for C, I, G, Inventories, X and M.

3 Production and purchasing power parities

The difference between price indices used for estimating purchasing, as opposed to producing power parities, reduces to a difference in how the prices of traded commodities are treated. For a given commodity *i*, and two countries *j* and *k*, the relative price for a particular commodity can be represented by:

$$PPP_{i,j,k} = \frac{p_{i,j}}{p_{i,k}} \tag{3}$$

Once a large number of commodity specific $PPP_{i,j,k}$ are calculated, index number theories can be used to aggregate the commodity specific relative prices into an overall purchasing power or producing power parity. In their bilateral form, the aggregate income purchasing power and producing power parities can be written as:

$$PPP_{j,k} = \sum w_i \frac{p_{i,j}}{p_{i,k}} \tag{4}$$

where w_i is the weight of the ith commodity. The commodity set employed will differ depending on whether a purchasing power or producing power parity is desired. In practice, the individual price relatives for a specific year (the reference year), are aggregated into expenditure categories and then weighted into an overall estimate used to deflate nominal incomes to produce a measure of relative real income for the reference year. The reference-year calculations use a bottom-up approach based on the individual commodities, and can produce estimates for overall income, and potentially for individual expenditure components and industries as well.

If the desire is a producing power parity measure that represents the difference in production levels, then the appropriate calculation for an international comparison employs either gross outputs and intermediate inputs through a value added calculation, or export and import prices which are examined separately.

The preferable approach is to use value added calculations for producing power parities that exploit the standard gross output minus intermediate inputs equation:

$$\sum p^{v}{}_{i,t} v_{i,t} - \sum p^{u}{}_{i,t} u_{i,t} \tag{5}$$

Assuming that prices for each output and input can be identified in both countries, the producing power parity is the difference between the gross output and intermediate input relative price indexes where the weights depend on the index employed:

$$PPP^{GDP}{}_{j,k} = \sum w^{v}{}_{i,t} \frac{p^{v}{}_{i,j}}{p^{v}{}_{j,k}} - \sum w^{u}{}_{i,t} \frac{p^{u}{}_{i,j}}{p^{u}{}_{j,k}} \tag{6}$$

Baldwin, Gu and Yan (2008) use this approach to estimate a producing power parity between Canada and the United States.

Alternatively, an expenditure-based GDP equation can be employed. When an additive index is used to represent the producing power parity, it can be written as:

$$PPP^{GDP}{}_{j,k} = w_C \frac{p_{C,j}}{p_{C,k}} + w_I \frac{p_{I,j}}{p_{I,k}} + w_G \frac{p_{G,j}}{p_{G,k}} + w_X \frac{p_{X,j}}{p_{X,k}} - w_M \frac{p_{M,j}}{p_{M,k}} \tag{7}$$

If the desire is for a purchasing power parity that represents differences in domestic absorption (i.e., purchasing power), then a common deflator should be used for trade flows:

$$PPP^{GDI}{}_{j,k} = w_C \frac{p_{C,j}}{p_{C,k}} + w_I \frac{p_{I,j}}{p_{I,k}} + w_G \frac{p_{G,j}}{p_{G,k}} + \left(w_X - w_M\right) \frac{p_{T,j}}{p_{T,k}} \tag{8}$$

The literature has developed a rationale for choosing the domestic final expenditure deflator as the common deflator for both exports and imports.[3] Use of this deflator allows differences between the volume measures of GDP and GDI to be decomposed into two easily interpreted terms (Kohli 2004; Macdonald 2007a, 2007b; Reinsdorf 2008). The first comes from trading gains that arise because of the increased consumption potential that is derived from changes in the terms at which exports can be traded for imports. The second is the gain that occurs because of changes in the 'real exchange rate'—the ratio of the price of nontradables to tradables—that also permit potential gains in the consumption or investment bundle purchased.

The producing power parity captures international differences in a nation's productive capacity, while the purchasing power parity captures differences in a nation's absorptive ability. For small open economies, the difference can be substantial, particularly if (like Canada), they rely on specific types of exports (such as energy products), whose price movements are substantially different from those of imports.

4 Differences in international practice

Understanding the difference between the purchasing power and producing power parity concepts is important because the two deflators are not calculated in the same way, giving rise to different measures of real volumes for cross-country comparisons. The various terms that are sometimes used in discussions have at the same time similar and different meanings.

A comprehensive set of National Accounts produces measures of economic activity in three ways that, when balanced, generate the same nominal estimate of overall economic activity. The production approach produces a measure of GDP by summing value added (the difference between gross output and intermediate expenditures) generated by the country's resident institutional industries. The expenditure approach sums all the final expenditures (consumption, investment, etc.) incurred by the country's resident institutional sectors. The income approach sums all the primary factor incomes earned by the country's resident institutional sectors engaged in domestic production. In nominal terms, output, expenditures and income should always equate, although they are the result of different ways of measuring the total value added

3. In the literature surrounding the System of National Accounts (SNA), the trading gain is derived by deflating net exports directly rather than using an implicit price deflator. The SNA presents several options for deflating net exports, including import prices, export prices, an average of import and export prices or a final domestic expenditure price index. Discussions of these alternative methods can be found in Geary (1961), Stuvel (1956), Denison (1981), Nicholson (1960), Courbis (1969), Kurabayashi (1971), Silver and Mahadavy (1989), the *SNA 1993*, Kohli (2004), and Macdonald (2007b).

of the production system. As a result, discussions of national income concepts like the *value* of income, or expenditure or production often refer to these three interchangeably. But when a measure of *volume* is produced to capture inflation-adjusted changes, these concepts are associated with quite different deflators and produce different volume measures. And it is at this level that the measures do not necessarily equate. It is when discussions of income do not adequately distinguish between the value or volume concepts that misconceptions arise.

Sometimes, agencies responsible for the production of PPPs inadvertently slip between the various meanings of income to which national accountants refer—production, expenditures or income. These are perfectly synonymous when used in nominal dollar values, but not the same when it comes to volume measures.

The *Methodological Manual on Purchasing Power Parities*, produced jointly by Eurostat and the Organization of Economic Co-operation and Development (OECD 2006, p. 26) stresses that the purpose of creating deflators (what it refers to as *purchasing* power deflators) for intercountry studies is to produce statistics that can compare "...differences in the volumes of goods and services *produced* [italics added] in countries. As such, they are *real* measures and measures of volume." The OECD then requires *producing* power deflators, not *purchasing* power deflators. Reinforcing this, the Manual (p. 33) stresses that the measures are meant "to make spatial volume comparisons of GDP (size of economies), GDP per head (economic welfare), and GDP per hour worked (labour productivity)." Real production measures are germane to comparisons of economic size and productivity—though they are not as appropriate for purposes of comparing economic welfare based on an ability to consume and invest in material goods. Relative GDI is germane to welfare type comparisons because real GDI, and economic welfare depend not just on the volume of production, but also on the volume of goods and services that can be purchased as a result of trade.

The PPP measure used by Eurostat/OECD makes use of the exchange rate to determine the relative price of import and export goods—which assumes the law of one price of traded goods. Making the assumption that a single price can be used to deflate exports and imports means that the OECD PPP estimate *approaches* that of the purchasing power concept—for the practical reason that this method means that the trade balance component in equation (8) reduces to a term appropriate for the purchasing power index—that is, net exports divided by a single price, in this case, the exchange rate. A purchasing power parity derived in this format will not usually be exactly the same as one based on the appropriate final expenditure relative price. Nevertheless, when the exchange rate is quite close to the ratio of the price of domestic expenditures, the OECD/Eurostat purchasing power parity may not be very different from the ratio that we have argued should be used for estimating purchasing power parity.

In contrast to the Eurostat/OECD practice, others in the international community argue that PPPs are meant to permit comparisons, not of productive capability but, of levels of 'welfare."[4] The World Bank (2004, p. 6) states that, "PPPs are most appropriate for comparing levels of welfare, which is why they are used in measuring global poverty."

We believe that the World Bank[5] has an implicitly larger concept of welfare in mind than just the volume of goods produced, since it explicitly defines welfare as dependent on "...the flow of goods and services available to countries to contribute to their economic well-being" and this depends on the rate at which exports can be exchanged for imports.

4. This distinction may not be quite as clear-cut as it appears, because while the OECD primarily makes reference to a production concept, it suggests that it can be used to examine welfare—though the latter is qualified as meaning GDP per head and therefore probably just refers to production capacity.
5. See the *ICP 2003-2006 Handbook*, chapter 1, p.1.

The CIA *World Factbook* adopts the same position, describing PPP-corrected GDP as "...the measure most economists prefer when looking at per capita welfare and when comparing living conditions."

This welfare concept is closely associated with differences in patterns of expenditures, not production. The World Bank specifically mentions the need to compare levels of consumption expenditures across countries, but intersperses its admonitions with the notion that total expenditures also need to be compared in order to compare levels of welfare. This tendency to interchange the concept of production and expenditure also occurs in the Eurostat/OECD Manual (OECD 2006, p. 2–3), when language is used that emphasizes that a PPP can be used to compare expenditures: "PPPs are used to convert national final expenditures on product groups, aggregates and GDP of different countries into real final expenditures." This language is unfortunate in that comparisons of real expenditures and real output require different deflators, as we have argued above.

While the World Bank makes use of language more in keeping with the real GDI concept, its measure is consistent with the formula used by Eurostat/OECD. As argued above, the measure that better captures differences in potential absorption is one that uses the final expenditure deflator for the net trade balance.[6]

In summary, the OECD/Eurostat program describes its program as one that measures *purchasing* power parity, but argues that it wants a *producing* power parity estimate and then makes use of an index that approximates a *purchasing* power deflator. The World Bank argues that it wants a *purchasing* power concept but then adopts a similar methodology to the measure used by OECD/Eurostat to generate its *producing* power deflator. As argued above, the confusion is resolved by adopting the correct income concept and by applying it to generate the purchasing power or producing power parity estimate appropriate to the purpose being contemplated.

5 Empirical reference-year calculations

In the following two sections, we will discuss practical problems in estimating purchasing power parities. Purchasing power parities are often calculated at intervals for specific reference years (benchmarks), and then projected forward until the next time period.[7] Different problems exist for the reference year and the projection calculations.

Calculating purchasing and producing power parities at benchmark years places different burdens on the statistical measurement system. Use of domestic expenditure bundles is straightforward in that it can make use of data on prices of commodities that the consumer price program and the investment or capital stock programs collect. Deriving data of reasonable quality for individual countries is straightforward since consumer and investment surveys normally exist that are based on representative sampling techniques that provide data of acceptable quality—though there may be difficulties in matching products of one country to another if consumption or investment bundles differ.[8]

6. See World Bank, *International Comparisons Project 2003-2006 Handbook*, Technical Notes.
7. Eurostat produces annual values of PPPs.
8. Commodity bundles may differ because of differences in consumer taste and differences in production systems. Matching investment commodities is particularly problematic when it comes to buildings and engineering projects.

Moving from a measure of purchasing power parity to a measure of producing power parity requires additional information about relative export and import prices or, if the producing power parity is calculated at the industry level, industry output and input prices.

The requisite data for dealing with import and export prices or cross-country comparisons of detailed prices for output and inputs at the industry level are less likely to be collected in national statistical systems. Because of this, efforts to generate producing power parity estimates attempt to overcome this problem in one of two ways.

5.1 Industry approaches to the producing power parity estimate

The first approach to calculating producing power parities uses commodity output and input prices for individual industries to create deflators for industry output (value added). This approach does not need to directly measure pass-through for exports and imports since it makes use of average prices received for domestic production and domestic inputs used in the production process.

One set of these studies estimates producing power parities using commodity data coming directly from firm-based surveys. This has been used mainly in the manufacturing industry, where statistical agencies have long collected detailed commodity data on outputs and inputs and their prices from firms so that commodity prices can be directly linked to industry output. The unit-value (UV) method uses unit values derived from the commodity data that are collected from the Survey of Manufactures of different countries. Unit prices are derived by dividing the value of shipments of certain commodities by the physical units that are produced of the same commodities. Since these values are calculated directly from factory shipments reported in the surveys that are used to calculate industry output from the activities of firms in the survey, they offer the advantage that the derived price directly applies to production.

This approach has been used to compare Canada/U.S. manufacturing productivity by West (1971) for 1963, by Frank (1977) and by Baldwin and Green (2009) for the 1920s.

The same technique has been used extensively to study productivity differences between European countries and the United States (Paige and Bombach 1959). Research studies carried out at the National Institute for Economic Research have compared Britain to the United States and Germany (Smith, Hitchens and Davies 1982; O'Mahoney 1992). Research studies associated with the Groningen Growth and Development Centre (see Maddison and van Ark 1988; van Ark 1992) have examined differences across a number of European countries.

There are several problems that the UV technique faces. One arises from the type of commodity data used and differences across countries in the commodity mix of industries. Unit values are often calculated for categories that are quite broad and that may involve a mix of heterogeneous commodities. As a result of this problem, cross-country comparisons are often restricted to a set of industries that produce a relatively homogenous commodity set. The prices of wheat and flour, for example, are easier to compare than the diverse range of chemical products, where there are often substantial differences in the type of commodities produced across countries.

Many international UV studies also face a problem in that commodity codes differ across the countries being compared. As a result, it is difficult to match similar commodities. And care must be given to adjust for quality differences—arising from sources as minor as differences in units of measurement. Gallons can be either imperial or U.S. gallons. Tons may be long or short tons. Even bricks can have differences in standard measures across countries.

As a result of problems in finding industries where commodities can be readily compared, many cross-country industry studies limit themselves to a handful of industries. For example, the Canada/U.S. comparison done by West (1971) used only 30 of about 100 three-digit manufacturing industries for which he felt had products that were homogeneous enough to permit comparisons. Frank (1977) examined only 33 industries. De Jong's 1996 comparison of Canada to the United States matched only about 27% of the total Canadian output for the derivation of the Canada/U.S. relative unit value (van Ark and Timmer 2001, p. 12). Baldwin and Gorecki (1986) extend the observation set for comparisons in the 1980s by modeling Canadian prices as a function of U.S. prices and the Canadian tariff for those industries where reasonable price comparisons could be made and then by spreading these estimates to other industries using tariff rates.

A separate approach to estimate producing power parities makes use of commodity data from input/output tables. The commodity price data coming from the expenditure categories that are collected by purchasing power parity programs are mapped to the commodity output matrices of the input/output tables to produce average prices that can be used to create average producing power parities for the commodity output of two countries. A similar procedure is then used to produce a commodity input deflator. When combined, these two measures provide an aggregate deflator for value added (the production measure at the industry level).[9]

Jorgenson and Kuroda (1990) use the relative commodity prices and input/output tables that combine both industry and commodity data to derive measures of prices that can be used for both outputs and inputs at the individual industry level. Lee and Tang (2001) perform the same exercise for Canada in 1995 by using some 201 relative commodity prices and matching them as best they could, to some 249 common but different commodity groups in the input/output tables.

This approach suffers from similar problems to that of the UV approach. First, not all the commodity categories from the input/output tables have a matched price from the expenditure price data—both because the number of prices collected for purchasing power parity programs is not large and secondly, because these programs focus on final expenditures and therefore have few intermediate input products.

These problems mean that current point estimates of producing power parities are probably less accurate than estimates of purchasing power parties.

5.2 Expenditure approach

Second, if the expenditure-based approach is used, an assumption about the relative price of import and export commodities is invoked. For example, Hooper (1996) and the Eurostat/OECD manual assume the law of one price—that an import price of a foreign good translates into a domestic price by the exchange rate.

$$PPP^{GDIApprox}{}_{j,k} = w_C \frac{p_{C,j}}{p_{C,k}} + w_I \frac{p_{I,j}}{p_{I,k}} + w_G \frac{p_{G,j}}{p_{G,k}} + \left(w_X - w_M\right) Forex_{j,k} \qquad (9)$$

9. This route is less direct than the UV approach since the expenditure programs that yield the average price data that are mapped to the industry level come mainly from consumer surveys, while the commodity categories from the industry accounts come from output data derived from firm-based surveys. Definitions of commodities are not always the same in each survey.

The resulting estimates will deviate from the correct purchasing power parity to the extent that the assumption about exchange-rate pass through is incorrect.

5.2.1 The assumption of exchange-rate pass-through

The *Princeton Encyclopedia of the World Economy* (2009, p. 377–378) notes that:

"Exchange rate pass-through can be defined as the degree of sensitivity of import prices to a 1% percentage change in exchange rates in the importing nation's currency. A closely related term is pricing to market, which refers to the pricing behaviour of firms exporting their products to a destination market following an exchange rate change. More to the point, *pricing to market* is defined as the percentage change in prices in the exporter's currency due to a 1% change in the exchange rate. Thus the greater the degree of pricing to market, the lower the extent of exchange rate pass-through."

"At one extreme, if import prices change by the same proportion as the change in the exchange rate, the result is full or complete pass-through and hence no pricing to market. At the other extreme, if exporters adjust prices in their own currency by the same proportion as the exchange rate change but in the opposite direction, the result is full pricing to market but no or zero pass-through of the exchange rate change to the destination market prices. More generally, if exporters alter the export prices in their own currency by a proportion smaller than the exchange rate, then exchange rate pass-through is said to be partial or incomplete."

Studies of pricing-to-market have been conducted for the period of the sharp appreciation of the Japanese Yen against the U.S dollar from 1994 to 1995 (Goldberg and Knetter 1997). If exchange-rate pass-through had occurred, buyers of Japanese products in the United States should have experienced substantial price increases. In fact, the price of Japanese cars sold in the United States rose only slightly and the price of some electronic items actually declined. Japanese firms exporting products to the United States absorbed a large part of the exchange-rate changes.

A number of other studies have examined the extent and the determinants of exchange-rate pass-through, and the corresponding pricing-to-market behaviour. Summaries can be found in Menon (1995a), Goldberg and Knetter (1997), and Reinert and Rajan (2009).

Research on exchange-rate pass-through in general finds that the local currency prices of foreign products do not respond fully to exchange rates. More specifically, incomplete pass-through is a common and pervasive phenomenon across a broad range of countries and there are significant differences in the rate of pass-through across countries. Pass-through tends to vary quite significantly across industries or product categories.

The average exchange-rate pass-through for the United States over the 1973-2003 period was 0.42; meaning that a 1% change in the value of the U.S dollar produced a 0.42% change in U.S. import prices. Similar conclusions apply to other OECD countries—the average pass-through is 0.64 over the same period (Carbaugh 2009).

The Canadian experience across exchange-rate cycles has been studied by Schembri (1989), Kardasz and Stollery (1998, 2001) and Baldwin and Yan (2007, 2008). Schembri (1989) and Baldwin and Yan (2007) find that Canadian exporters price discriminate between the domestic (Canadian) and U.S. market by limiting the pass-through of exchange rate changes to their export price, preferring instead to swell or squeeze their profit margins over exchange-rate cycles.

5.2.2 Factors that impact on the size of pass-through

The theoretical explanations of incomplete pass-through have emphasized the role of market structure, product differentiation and market segmentation. Both the degree of substitutability of domestic and imported goods, and the degree of market separation determine the price-setting power of firms, and will affect the leverage available to them in responding to exchange-rate changes. The lower the degree of product differentiation and market integration, the greater will be the market power of sellers. The degree of exchange-rate pass-through has been found to be associated with measures of market concentration, product differentiation and market separation (Dornbusch 1987; Sibert 1992; Kardasz and Stollery 2001; Feinberg 1989; Bloch and Olive 1999; Krugman 1987; Knetter 1989; Marston 1990; Gagnon and Knetter 1995).

Other factors that affect the pass-through include the cost of price changes, the currency used to invoice intercountry transactions, the extent of intra-firm trade among multinational corporations, and outsourcing.

The cost of changing prices affects the speed with which price pass-through occurs after changes in exchange rates. The types of transaction costs associated with re-pricing and reputation effects as well as sunk costs associated with the establishment of a distribution and after-sales network reduce the speed with which firms pass through what they may interpret as temporary fluctuations in exchange rates (Frankel and Rose 1995; Menon 1995b; Kasa 1992; Krugman 1988; Dixit 1989; Baldwin 1988).

The currency of invoicing also affects the degree of exchange rate pass-through. When exports are invoiced in the currency of importers, exchange-rate changes have little effect on the import prices in the importing country, leading to low exchange-rate pass-through. On the other hand, when exports are invoiced in the currency of exporters, exchange-rate changes have a greater effect on the import prices in the importing country, leading to higher pass-through. Carbaugh (2009) reports that the U.S. dollar is the dominant currency of invoicing across non-European countries: 92.8% of U.S. imports and 99.8% of U.S. exports were priced in U.S. dollars in the early 2000s. The use of U.S. dollars in invoicing helps to explain the partial pass-through of exchange rate changes to U.S. import prices. The fluctuation of the U.S. dollar will not be passed through to import prices in the United States, at least in the short run, since the price of these imported goods remains fixed in the U.S. dollar.

Intra-firm pricing policies employed by multinational corporations can also prevent the full transmission of exchange-rate changes to selling prices in individual markets (Dunn 1970; Menon 1993; Menon 1995a). Transfer prices between subsidiaries of multinationals are subject to scrutiny by tax authorities and therefore multinationals may be slow to change them in response to movements in exchange rates because this will lead to new, possibly protracted negotiations with local tax authorities.

Finally, it has been argued that recent changes in economic structure coming from increased foreign outsourcing has lead to even less pass-through of exchange rates (Athukorala and Menon 1994; Campa and Goldberg 1995; Türkcan 2005; Hellerstein and Villas-Boas 2009). Outsourcing has lead to a decline in the share of costs incurred in the home currency, which mutes exchange-rate pass-through. A depreciation of the currency of the country exporting final products makes imported intermediate inputs more expensive. The increasing input costs raises the costs of exports, and therefore dampens the exchange rate pass-through that otherwise would lead to decreases in the prices of exports.

All this suggests that making a general assumption that export and import prices can be treated as essentially the same across countries (except for exchange rate corrections) is likely to lead

to imprecision in producing power estimates. This is particularly so for Canada. Empirical evidence for Canada that compares Canadian and U.S. expenditure prices or industry output prices suggests that the law of one price does not hold at every point in time, and may not even hold on average over long periods of time (Baldwin and Yan 2004, 2007, 2008). Microdata used by the National Accounts to estimate the change in the volume of exports and imports also suggests that export and import prices have not adjusted perfectly to changes in exchange rates after 2002. Moreover, the results of Baldwin and Yan (2004) suggest that the level of Canada/U.S. prices varies over time. This means that producing power parity estimates that assume perfect pass-through contain an error and their accuracy may vary over time when exchange rates fluctuate dramatically—as has been the case in Canada more recently.

In light of these problems, if an exchange-rate related assumption is being made in order to generate a producing power parity, it may be desirable to experiment with alternate assumptions about pass-through (see Hooper 1996) in order to produce a set of estimates that generate a confidence interval that users can employ in their analyses.

6 Extrapolation and interpolation

When the base-year estimate of the purchasing power parity is projected forward, present OECD practice involves the use of relative GDP deflators.

These extrapolations produce estimates that have increasingly required substantial revision at the next benchmark and therefore appear to be inaccurate. This occurs because changes in the benchmark real measures capture changes in production volumes as well as dramatic changes in the terms of trade. While the OECD claims to be measuring producing power parity, it is actually producing a measure of purchasing power parity.

The OECD reference years and extrapolations treat the terms of trade in fundamentally different ways as we demonstrate below: The reference-year calculations treat the terms of trade as a volume effect while the extrapolations treat the terms of trade as a price effect.

As a result, the estimate of purchasing power parity that is projected forward from the benchmark reference year using the relative movements in GDP deflators can be substantially different from reference year purchasing power parity estimates when terms-of-trade shocks occur.

In order to understand why the present projection system produces estimates of purchasing power parities that need such dramatic revision at new benchmark years, it is important to understand the relationship between price deflators that are appropriate for estimating real GDI (the real income concept) and real GDP (the real production concept).

In order to extrapolate a benchmark purchasing power parity using National Accounts data, it is necessary to generate chain indices to project reference years. The Tornqvist formula is used here to illustrate the connection between the two indices—the implicit GDI and the implicit GDP indexes. The Tornqvist index has the advantage of being log-additive, which means that the components of the decomposition can be interpreted as the contribution of each term to growth of the overall index. Diewert (1978) shows that the Tornqvist index is equivalent to a second-order approximation to the Fisher ideal index, making its growth rates comparable to National Accounts Fisher aggregates, to two decimal points.

Define the logged Tornqvist projector index between periods t and s as the difference between U.S. and Canadian price indices:

$$\ln\left(PPP_t / PPP_s\right) \equiv \sum_{i=1}^{N} \overline{v}_{US,i,t} \ln\left(p^{US}_{i,t} / p^{US}_{i,s}\right) - \sum_{i=1}^{N} \overline{v}_{Can,i,t} \ln\left(p^{Can}_{i,t} / p^{Can}_{i,s}\right) \tag{10}$$

where, $i = 1,\ldots,N$ commodities,

$$\overline{v}_{j,i,t} = \left(\frac{\varpi_{j,i,t} + \varpi_{j,i,s}}{2}\right) \text{ and } \varpi_{j,i,t} = \frac{y_{j,i,t} p_{j,i,t}}{\sum y_{j,i,t} p_{j,i,t}} \; ; j = \text{Canada, US}.$$

The GDP deflator is calculated by summing across all N commodities, while the GDI deflator is calculated by summing across all domestic commodities.

By aggregating categories so that domestic expenditures and trade data are treated separately, the purchasing power parity projector changes can be written as:

$$\begin{aligned} \ln\left(PPP^{GDI}_t / PPP^{GDI}_s\right) &\equiv \sum_{i=1}^{N_{fdc}} \overline{v}_{US,i,t} \ln\left(p^{US}_{i,t} / p^{US}_{i,s}\right) - \sum_{i=1}^{N_{fdc}} \overline{v}_{Can,i,t} \ln\left(p^{Can}_{i,t} / p^{Can}_{i,s}\right) \\ &= \ln\left(p^{US}_{fdc,t} / p^{US}_{fdc,s}\right) - \ln\left(p^{Can}_{fdc,t} / p^{Can}_{fdc,s}\right) \end{aligned} \tag{11}$$

Similarly, the producing power parity projector changes can be written as the difference between GDP deflator changes. The producing power parity projector can also be viewed as the weighted average of changes in the purchasing power parity projector and changes in trading gains (i.e., the terms of trade):

$$\begin{aligned} \ln\left(PPP^{GDP}_t / PPP^{GDP}_s\right) &\equiv \sum_{i=1}^{N} \overline{v}_{US,i,t} \ln\left(p^{US}_{i,t} / p^{US}_{i,s}\right) - \sum_{i=1}^{N} \overline{v}_{Can,i,t} \ln\left(p^{Can}_{i,t} / p^{Can}_{i,s}\right) \\ &= \overline{v}_{US,fdc,t} \ln\left(p^{US}_{fdc,t} / p^{US}_{fdc,s}\right) - \overline{v}_{Can,fdc,t} \ln\left(p^{Can}_{fdc,t} / p^{Can}_{fdc,s}\right) \\ &+ \overline{v}_{US,T,t} \ln\left(T^{US}_t / T^{US}_s\right) - \overline{v}_{Can,T,t} \ln\left(T^{Can}_t / T^{Can}_s\right) \end{aligned} \tag{12}$$

In the case of the GDP deflator, relative price changes coming from trading gains are subsumed in the deflator. As a result, a volume measure based on a GDP deflator tracks differences in production. In the case of the GDI deflator, the trading gain is treated as a volume measure that influences the real expenditures of the domestic economy. It is interpreted as an adjustment to domestic production for changes in purchasing power originating from relative prices associated with trading activities.

In the case of the U.S.-Canada bilateral purchasing power parity program, there are two goals. The first is to produce a measure in nominal dollars that can be used to compare per capita incomes in level terms. The second goal is to compare the relative growth in the level of real income between Canada and the United States. In either case, it is necessary to employ the appropriate producing power or purchasing power parity index for translating Canadian dollars into U.S. dollars. Imperative to this process is a consistent treatment of the terms of trade.

Take, for example, a sequence of nominal incomes in Canada relative to the United States:

$$\frac{P^{Can}_{GDP,t} \times Q^{Can}_{GDP,t}}{P^{US}_{GDP,t} \times Q^{US}_{GDP,t}}, \frac{P^{Can}_{GDP,t+1} \times Q^{Can}_{GDP,t+1}}{P^{US}_{GDP,t+1} \times Q^{US}_{GDP,t+1}}, \frac{P^{Can}_{GDP,t+2} \times Q^{Can}_{GDP,t+2}}{P^{US}_{GDP,t+2} \times Q^{US}_{GDP,t+2}} \tag{13}$$

In this form, the comparison is of limited use because nominal income in each country is measured in respective nominal currencies. If a producing power parity deflator is used to transform Canadian prices into U.S. prices, the resulting sequence of relative real income is equivalent to changes in relative production:

$$\frac{Q^{Can}_{GDP,t}}{Q^{US}_{GDP,t}}, \frac{Q^{Can}_{GDP,t+1}}{Q^{US}_{GDP,t+1}}, \frac{Q^{Can}_{GDP,t+2}}{Q^{US}_{GDP,t+2}} \tag{14}$$

If a purchasing power parity deflator is employed to transform Canadian dollars into U.S. dollars, the resulting sequence of volume measures include production, as well as an effect from the trading gain:

$$\frac{T^{Can}_{t} \times Q^{Can}_{GDP,t}}{T^{US}_{t} \times Q^{US}_{GDP,t}}, \frac{T^{Can}_{t+1} \times Q^{Can}_{GDP,t+1}}{T^{US}_{t+1} \times Q^{US}_{GDP,t+1}}, \frac{T^{Can}_{t+2} \times Q^{Can}_{GDP,t+2}}{T^{US}_{t+2} \times Q^{US}_{GDP,t+2}} \tag{15}$$

When a purchasing power parity deflator is employed, as Canada's terms of trade improves, so too does its standing relative to the United States. Similarly, an improvement in the terms of trade in the United States increases its relative real income compared to Canada.

Since the present reference-year calculations employ a type of GDI concept that produces a set of relative volumes where production and the trading gain influence real incomes, the projector using the GDI deflator is the appropriate index for extrapolating purchasing power parity measures through time. Extrapolations and interpolations, made using GDP deflators between reference years (and from the latest reference year up to the most recently published National Accounts data), generate a hybrid result because the reference years and extrapolations treat the terms of trade in fundamentally different ways: The reference-year calculations treat the terms of trade as a volume effect, while the extrapolations treat the terms of trade as a price effect.

The current procedure for projecting the purchasing power parity deflator estimates from the most recent reference year to the latest available National Accounts data mixes GDI and GDP deflators. The following sequence of purchasing power parity deflator estimates for the U.S.-Canada bilateral purchasing power parity is employed:

$$\frac{p^{US}_{fde,t}}{p^{Can}_{fde,t}}, \frac{p^{US}_{GDP,t+1}}{p^{Can}_{GDP,t+1}}, \frac{p^{US}_{GDP,t+2}}{p^{Can}_{GDP,t+2}}, \frac{p^{US}_{GDP,t+3}}{p^{Can}_{GDP,t+3}} \tag{16}$$

This leads to a comparison of deflated volume aggregates that link and project domestic absorption using movements in production:

$$\frac{T_t^{Can} \times Q_{y,t}^{Can}}{T_t^{US} \times Q_{y,t}^{US}}, \frac{Q_{y,t+1}^{Can}}{Q_{y,t+1}^{US}}, \frac{Q_{y,t+2}^{Can}}{Q_{y,t+2}^{US}}, \frac{Q_{y,t+3}^{Can}}{Q_{y,t+3}^{US}} \tag{17}$$

Three years after the extrapolation is initially produced, the reference year at $t+3$ is updated. The updated reference year calculation uses a GDI rather than a GDP income concept to replace the projected purchasing power parity deflator estimate. As long as terms-of-trade changes are small, the linking can produce approximately correct results for the desired comparison in equation (15). However, if the terms of trade change significantly between reference years, then the new reference year will not be approximately equal to the projected estimate: $\frac{P_{fde,t+3}^{US}}{P_{fde,t+3}^{Can}} \neq \frac{P_{GDP,t+3}^{US}}{P_{GDP,t+3}^{Can}}$. The purchasing power parity will, therefore, require important revisions because an inappropriate projection method is employed for inter-temporal extrapolations.

7 Empirical results

7.1 Level purchasing power parities from projectors

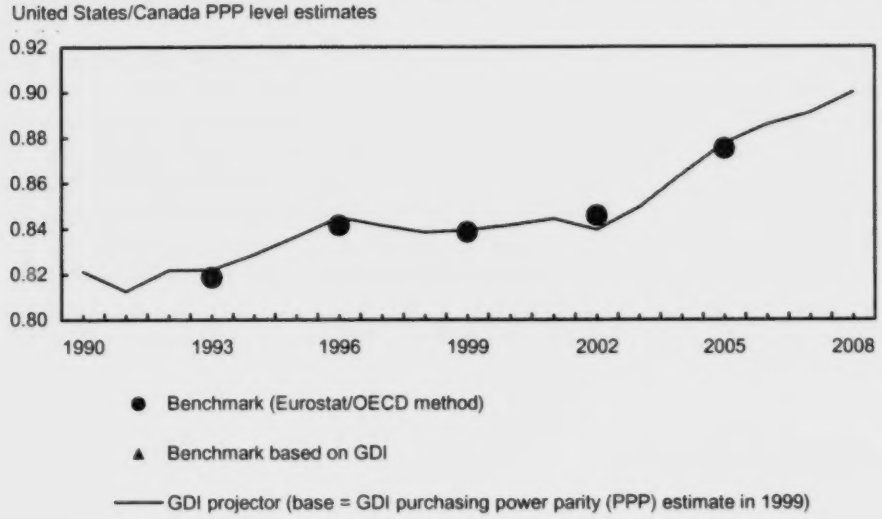
In this section, we provide estimates of the purchasing power index between Canada and the United States that is relevant to the real GDI income concept, and compare it to present estimates based on the Eurostat/OECD methodology. The purchasing power parity is defined as the ratio of the U.S. price divided by the Canadian price. When the purchasing power parity is one, a U.S. dollar buys the equivalent bundle of goods in the United States that a Canadian dollar would in Canada. If it takes a value of 0.80, then only 80 cents is required in the United States to buy what a Canadian dollar buys in Canada. Since the purchasing power parity so estimated is used to multiply ratios of Canadian expenditures to U.S dollars when comparing real income, the larger is the purchasing power parity (as defined above), the better off are Canadians.

In Chart 2, we present the estimate of purchasing power based on the real GDI-concept for 1999 and then project it forward and backward using final expenditure estimates of Canada/U.S relative prices taken from their respective national accounts. Numerical estimates are presented in Table 1. We also plot the estimates that are produced when we follow the present Eurostat/OECD estimation procedure. It is clear that the purchasing power estimates closely track the actual estimates derived from the Eurostat/OECD methodology—thereby reinforcing the observation that the present indices are close to purchasing not producing power estimates.

We also project the 1999 estimates forward in time using the relative GDP deflators, as is the present practice for projecting the PPP between benchmark years. The projected path for the U.S.-Canada bilateral purchasing power parity after 2002 is significantly different, depending on the projector employed (Chart 2). The GDP projector has a negative trend, implying that Canada's purchasing power decreased relative to U.S. purchasing power as Canada's terms of trade improved after 2002. The trend is interpreted as Canada faring worse than the United States as energy and non-energy commodity prices rose. The GDI deflator has a positive trend, implying that higher commodity prices increased Canada's well-being relative to the United States. It is significant that the new benchmark estimate for 2005 approximates the extrapolated

result from the GDI-based projector, not the estimate that would have been produced by the GDP-based projector.

Chart 2
PPP base-year level estimates and extrapolations through time



Admittedly, the terms-of-trade adjustments after 2002 are large by historical standards, making the 2000 to 2008 period unusual. The terms-of-trade adjustments led to a large adjustment in the terms-of-trade component of the producing power parity projector, by creating large changes in the trading gains component in equation (11). At the same time, however, the very size of the terms-of-trade adjustments emphasises both the difficulty of using GDP deflators for projecting purchasing power parities, and that present extrapolation techniques do not reflect purchasing power parities since they undergo such radical revisions at benchmark years.

We also project back in time from 1999, using both relative GDI deflators and relative GDP deflators (Table 1). On average, the GDP projector generates larger errors than the GDI deflators when projected values are compared to reference years; but the error for the GDP backward projectors is much smaller than it was for 2005. This is because differences in Canadian and U.S. terms of trade are much smaller in the earlier period.

In summary, the estimates of purchasing power parity derived from the Eurostat/OECD method do not track changes in relative GDP deflators in the two countries. The measure tracks movements in relative GDI deflators—because, as we have argued, this ratio is really a proxy (albeit an imperfect one),[10] for a purchasing power index.

10. Except in special circumstances where the law of one price holds for both imports and exports.

Table 1
PPP Projector estimates versus reference year estimates

	Benchmark GDI	GDP projector	GDI projector	GDP error	GDI error	GDI/GDP error
		ratio			percent	ratio
Levels						
1993	0.82	0.82	0.82	-0.3	0.5	-1.8
1996	0.84	0.83	0.84	-2.2	0.2	-0.1
1999	0.84	0.84	0.84	--	--	--
2002	0.85	0.84	0.84	-0.9	-0.9	0.9
2005	0.88	0.83	0.88	-5.6	0.2	0.0
Errors						
Average error	...	...	...	-2.2	0.0	0.0
Average absolute error	...	...	...	2.2	0.4	0.2
			percent			ratio
3-year-average growth rates						
1993 to 1996	1.0	0.4	0.9	-0.7	-0.1	0.1
1996 to 1999	-0.2	0.6	-0.2	0.7	-0.1	-0.1
1999 to 2002	0.3	0.0	0.0	-0.3	-0.3	0.9
2002 to 2005	1.2	-0.5	1.5	-1.6	0.4	-0.2
Errors						
Average error	...	...	...	0.1	0.1	0.9
Average absolute error	...	...	...	0.8	0.2	0.2

Note: GDI stands for gross domestic income; GDP stands for gross domestic product.

7.2 Level of producing power parities from projectors

Measuring a producing power parity is more difficult than measuring a purchasing power parity because statistical systems are not pre-disposed to gathering detailed, internationally comparable, estimates of import and export commodities in a manner analogous to the data collected for purchasing power estimates that need only make use of readily available expenditure-based prices.

Nevertheless, using the gross output and intermediate inputs for calculating a producing power parity, Baldwin, Gu and Yan (2008) generate a U.S.-Canada producing power estimate of 0.83 for the business sector and 0.85 for total GDP in 1999. While these estimates of producing power parity are consistent with calculating GDP rather than GDI, they are less accurate than the purchasing power estimates for the reasons argued above. In a number of instances, averages of prices for commodities are used to estimate missing data points, which probably induce larger measurement errors than those found in purchasing power estimates. The analytical estimate produced by Baldwin, Gu and Yan has a wider confidence interval than the purchasing power expenditure estimate that can be produced from data collected for the official purchasing power parity program.[11]

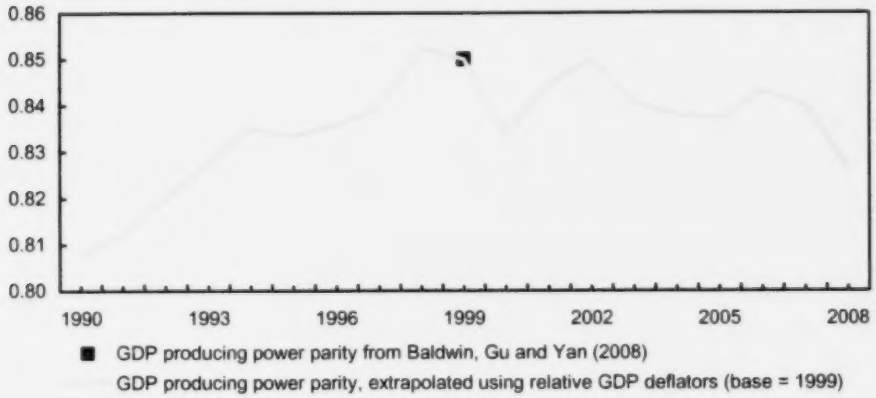
Baldwin, Gu and Yan's producing power estimate is used as a base year, and the ratio of U.S. and Canadian GDP time series deflators are used to extrapolate the producing power estimate through time (Chart 3). The largest difference that emerges relative to the GDI-based

11. One way to evaluate the size of the bounds that should be used is to compare two estimates that use the same data, but are produced by two independent teams. Baldwin, Gu, and Yan report that Rao, Tang and Wang (2004) make use of the same commodity data from the Canadian input/output tables and slightly different assumptions about commodity splits by industry and obtain a PPP estimate of 0.88 compared to the 0.85 estimate produced by Baldwin, Gu, and Yan used here.

purchasing power estimate between 1990 and 2008 occurs after 2002 as the terms of trade of Canada and the United States adjusted to rising commodity prices (Chart 4).

Chart 3
Producing power parity level estimate and extrapolation through time

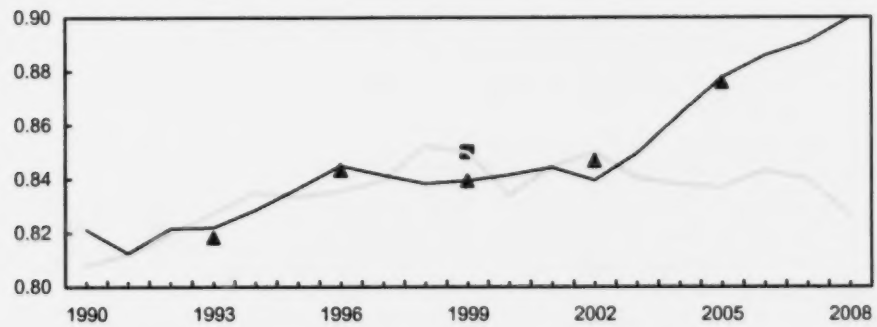
GDP-based United States/Canada PPP level estimate (ratio)



■ GDP producing power parity from Baldwin, Gu and Yan (2008)
GDP producing power parity, extrapolated using relative GDP deflators (base = 1999)

Chart 4
Purchasing power parity versus producing power parity level estimates and extrapolations through time

GDP-based versus GDI-based United States/Canada PPP level estimates (ratio)

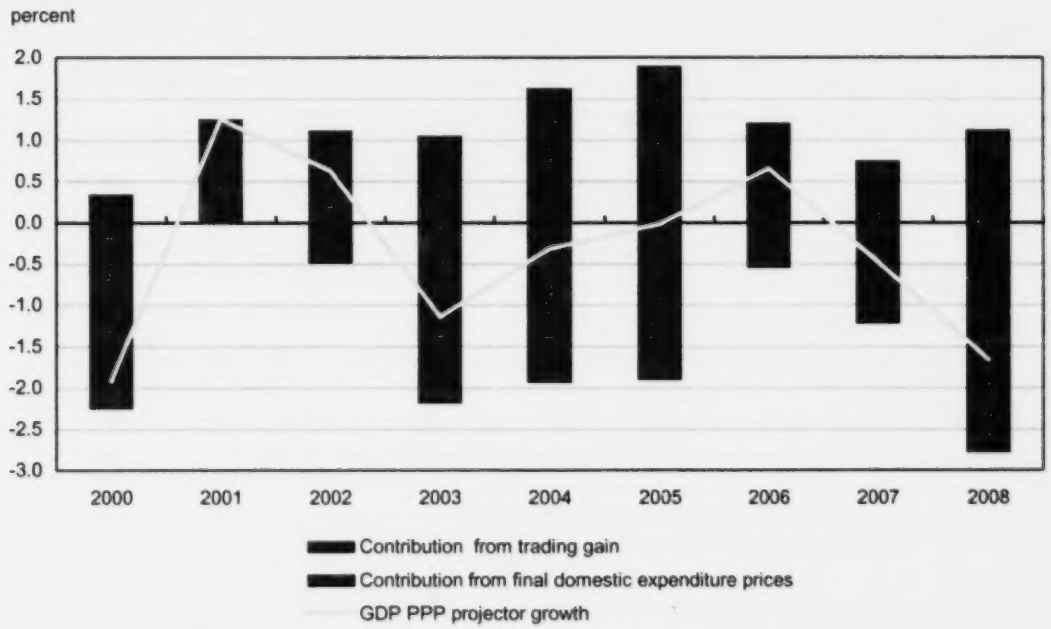


■ GDP producing power parity from Baldwin, Gu and Yan (2008)
▲ GDI purchasing power parity
GDP producing power parity, extrapolated using relative GDP deflators (base = 1999)
GDI purchasing power parity, extrapolated using relative FDE deflators (base = 1999)

8 Decomposed growth factors

Between 2002 and 2008, growth in producing and purchasing power parity projectors were negatively correlated because of the terms-of-trade adjustment. Over this period, terms-of-trade adjustments were sufficiently strong to dominate domestic price movements in the producing power parity estimate. As a result, the producing power parity projector tended to decline after 2002, while the GDI-based purchasing power parity projector increased. The difference between the two sources of price growth can be illustrated by examining the contributions to growth (Ctg) from domestic prices and the trading gain using the decomposition in equation (12). In six of the years between 2000 and 2008, the trading gain contribution is larger than the domestic price contribution to the producing power parity growth (Chart 5). In those years where the contribution of the trading gain outweighs the contribution of domestic prices, the producing power parity estimate will have a growth rate with the opposite sign of the purchasing power parity estimate. That is, the producing and purchasing power parity growth rates will be negatively correlated. Thus, the interpretation of how Canada's purchasing power evolved relative to the United States depends crucially on how the terms of trade are treated.

Chart 5
GDP-based PPP growth decomposed into contributions from domestic price growth and the trading gain



Note: Based on Equation 12.

If the terms of trade are treated as a volume movement and a purchasing power parity projector is employed, the projector shows an improvement in Canada's purchasing power relative to the United States. This result accords with examinations of real GDI growth between the two countries. If the producing power parity projector is employed, it appears that Canada's purchasing power declined relative to the United States, contrary to expectations given by the actual terms-of-trade movements in the two countries.

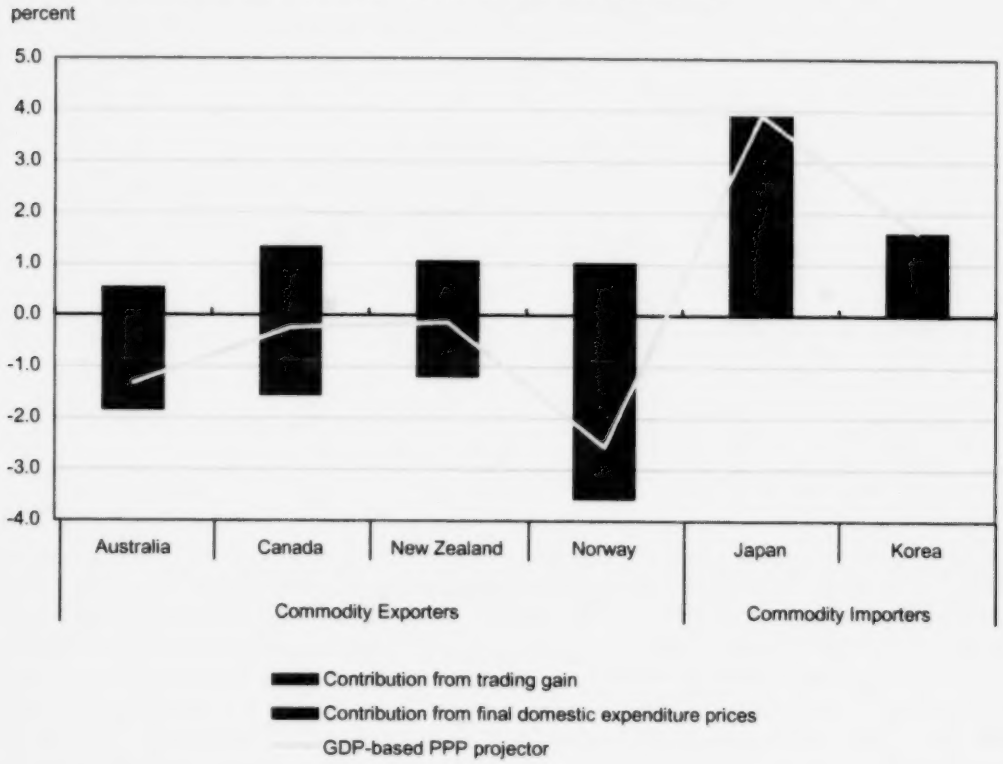
Canada is not the only nation where trading gains influence the path of projected producing and purchasing power parity movements after 2002. The decomposition of producing power parity projectors in equation (12) is recalculated, comparing sources of purchasing and producing power parity growth for the United States to those of Australia, Canada, New Zealand, Norway, Korea and Japan (Chart 6). Reference years are not examined: only changes through time in the projectors for producing power parity estimates are. These countries are selected because they represent commodity exporters and commodity importers, which experienced significant terms-of-trade changes after 2002 (Macdonald 2010). For each pair of countries, the graph contains the relative GDP deflators along with the contribution to growth (Ctg) of each country's final domestic prices and trading gains.

In commodity exporting countries where the terms of trade increased between 2003 and 2007, the contribution of the trading gain to the producing power parity outweighed the contribution of domestic prices, which leads to a negative correlation between growth in the purchasing power and producing power parity estimates (Chart 6). In Canada, Australia, New Zealand and Norway, the perverse effects from the terms of trade on the producing power parity projector are sufficiently large to change the trend of the data (Table 2). The opposite occurs in commodity-importing nations, although the effect is not as large. In Korea and Japan, the contribution of the trading gain reinforces movements in final domestic prices creating growth in the producing power parity deflator that is faster than their purchasing power parities. Using the GDP deflator to project the purchasing power parities for these commodity importers leads to larger changes than using the appropriate GDI-based projector.

Table 2
Average annual growth in GDP-based PPP decomposed into contributions from domestic price growth and the trading gain, 2003/2007

Country	Contribution from final domestic price growth	Contribution from the trading gain	GDP-based PPP projector
	percent		
United States/Australia	0.3	-1.6	-1.3
United States/Canada	1.0	-1.1	-0.1
United States/New Zealand	1.0	-0.9	0.1
United States/Norway	0.9	-2.4	-1.5
United States/Japan	3.5	0.3	3.8
United States/Korea	0.4	0.7	1.2

Chart 6
Average annual growth in GDP-based PPP decomposed into contributions from domestic prices growth and the trading gain, United States versus select OECD Nations, 2003/2007



Note: Based on equation 12.

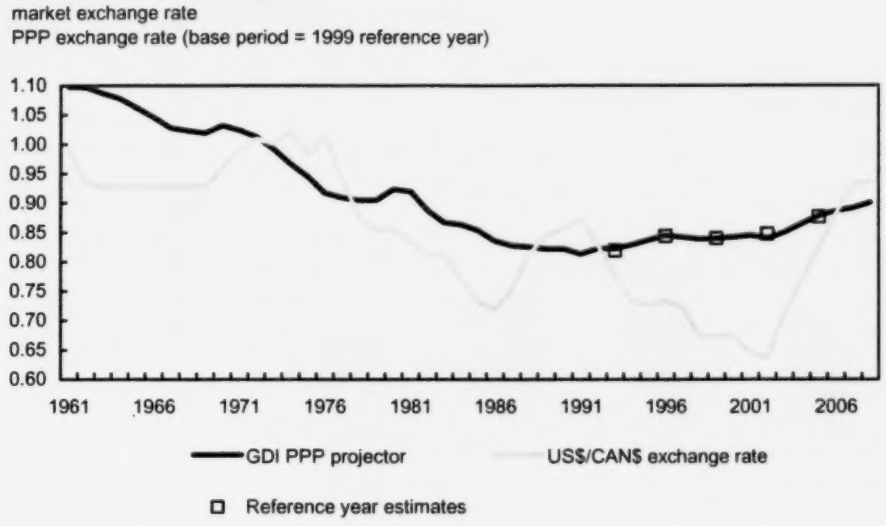
9 Historical backcasting of purchasing power parities

In this section, we take our benchmarks and backcast them over time. The current Canadian System of National Accounts data extend back to 1961, while the data for the United States extend back to 1929. Consequently, it is feasible to backcast purchasing power parity levels with reasonable confidence to 1961 for Statistics Canada's bilateral purchasing power parity program, as both Canadian and U.S. chain data are available for this time period.

Longer-run estimates must always be viewed with caution. Data collection systems, definitions and index aggregation differences can all lead to variations in data quality and accuracy over long periods of time.

The trend in the purchasing power parity from 1961 to 2005 is plotted in Chart 7. The trend slopes downward from 1961 to around 1999 and thereafter it increases. The period after 2002 is marked by a particularly large gain.

Chart 7
GDI-based PPP exchange rate versus United States/Canada market exchange rate

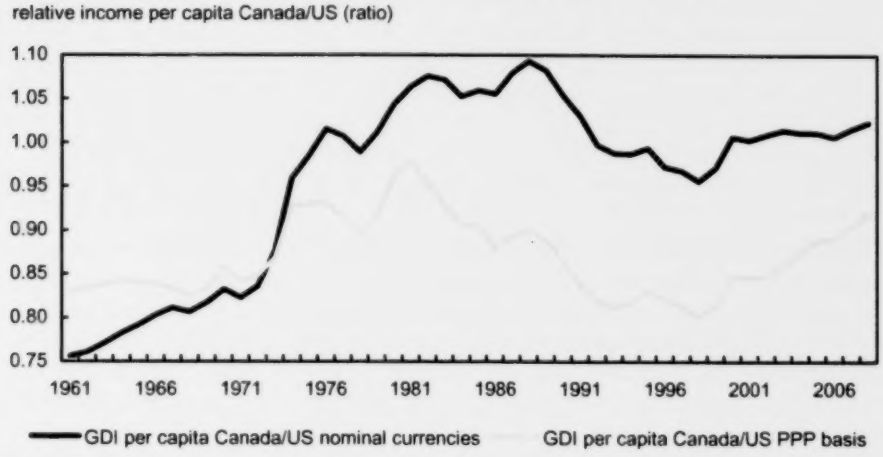


Purchasing power parities are used to transform dollar values, measured in varying currencies, into a common numéraire. A less complex alternative is the exchange rate. Exchange rates and PPP estimates are expected to move in tandem over long periods of time. The long-term movements from 1961-2000 in both the GDI deflator and the Canada/United States exchange rate are downward, and both move upward after 2000. But, there are periods when changes in the PPP and the exchange rate move in opposite directions. It is also apparent that the level of the PPP and the level of the exchange rate generally differed over the entire time period—with the exception of the years around 2000. These data illustrate the inadequacy of using an exchange rate as a proxy for the purchasing power parity deflator throughout this period.

The purchasing power parity projector can be employed to calculate level comparisons of income between Canada and the United States over the 1961-2008 period. From 1961 to the first oil shock, Canadian income levels are about 83% of U.S. income levels (Chart 8). Rapid increases in oil prices in 1972/1973 and 1979/1980 reduce U.S. purchasing power and increase Canadian purchasing power through terms-of-trade shifts. For the United States, the terms of trade decline 51% during the ten years between 1971 and 1980. During this period, Canadian relative income increases, from 84% of the U.S. level in 1971, to 98% of the U.S. level in 1980.

Canada eventually returns to an income level approximately 20% lower than the U.S. level as the effects of the oil shocks are unwound. However, the adjustment is gradual, spanning 12 years from 1981 to 1992. By 1992, the Canadian income level was 82% of the U.S. real income level. For the remainder of the 1990s, the Canada–United States relative income level is stable. After 1999, Canada gains ground on the United States when energy prices rise. Between 1999 and 2008, Canadian relative income rises from 82% of the U.S. level to 92% of the U.S. level.

Chart 8
Income per capita comparison: Canada versus United States unadjusted and adjusted for purchasing power differences



10 Conclusion

Comparisons of national income across countries require deflators. The type of deflator depends on the purpose for which it is to be used. We argue here that two types of deflators can be chosen for cross-country comparisons—just as two different types of deflators are used to produce time series volume estimates of 'real' GDP or volume estimates of 'real' GDI.

The first type can be referred to as producing power deflators. They are needed to compare production. The second type can be referred to as purchasing power deflators. They are needed to compare estimates of domestic absorption.

While the differences between these concepts are well recognized in national accounting circles for estimates of production growth, they do not appear to have been appreciated by the international agencies that produce estimates of purchasing power parities for cross-country comparisons.[12] Indeed, literature on the subject is often characterized by the interchangeable use of terms like 'production' and 'expenditures,' which while appropriate when referring to nominal estimates of national income, are imprecise when volume concepts are discussed.

We argue here that the purchasing power concept is straightforward, and that it can be readily estimated, using available data on expenditures, to provide a measure of reasonable quality, and we illustrate how it can be used to track Canada–United States purchasing power parities since 1961.

In contrast, estimates of producing power parity are more problematic for various empirical reasons surrounding the difficulty of measuring the relative prices of gross outputs and intermediate inputs, or exports and imports. Supporting this argument (that the present measures of producing power parity are of poor quality), we observe that current purchasing power parity estimates that purport to measure the relative size of national economies track relative GDI (albeit imperfectly since they do not use an expenditure deflator for the net trade

12. For a recent academic article that recognizes the differences, see Feenstra et al., 2009.

balance) and not relative GDP. Where estimates of a producing power parity exist, the estimate is probably less accurate than the purchasing power parity estimate.

Our conclusion is that statistical agencies are presently better able to estimate purchasing power deflators for cross-country comparisons. An adjustment for export and import prices that is required to generate producing power estimates is unnecessary for purchasing power estimates. While producing power deflators are desirable, and research has generated level estimates between the United States and Canada for some years, there is limited scope for their estimation on an ongoing basis until the quality of producing power estimates can be proven. And, if they are to be produced, effort needs to be given to obtaining more precise estimates of the relative prices of gross outputs and intermediate inputs (or exports and imports), and of the confidence intervals that should be applied to producing power measures.

11 Glossary of Terms

Purchasing Power Parity: A relative measure of the prices of consumption and investment goods and services between countries. Purchasing power parity estimates are associated with domestic absorption and correspond to price adjustments associated with a representative agent's utility function. It is often viewed as an exchange rate and is appropriate for examining differences in income-based living standards. For a U.S.-Canada comparison, a purchasing power parity of 0.84 is interpreted to mean that a U.S. citizen would spend 84 cents to purchase a bundle of goods and services that would cost a Canadian citizen $1.00.

Producing Power Parity: A relative measure between two countries of the prices of goods and services that those countries produce. Producing power parity estimates are appropriate for comparing country's production possibility frontiers and examining the relative size of economic output or productivity. Producing power parities are typically more difficult to measure than purchasing power parities because internationally comparable data on intermediate products are less accessible.

Terms of Trade: The ratio of export prices to import prices. The terms of trade represent the number of exports that must be sent abroad to purchase an import. A terms of trade improvement enhances welfare in the domestic economy by expanding the volume of goods and services available to citizens, businesses and governments in a manner analogous to productivity growth.

Trading Gain: A measure of the benefit or detriment that accrues to an open economy from trade-related relative price changes. Two relative price changes are combined in the trading gain in this paper: the relative price of traded to non-traded goods and services, and the terms of trade. The terms of trade have, in Canada's case, the quantitatively more important effect. An increase in the trading gain signals an increase in the consumption and investment possibilities available to an open economy.

Real Gross Domestic Product: An inflation adjusted measure of the value added generated by an economy. Real GDP is associated with an economy's production function.

Real Gross Domestic Income: An inflation adjusted measure of the volume of domestic purchases that may be made using domestic production. Changes in real GDI come from changes in production (real GDP growth) and from changes in the purchasing power of domestic production (the trading gain).

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